422 Rec'd PCT/PTO 22 MAY 2000

FORM PTO-1390 (Modified) (REV 10-95) U.S. DEPARTMENT OF COMMERCE PATENT AND TRADEMARK OFFICE

TRANSMITTAL LETTER TO THE UNITED STATES DESIGNATED/ELECTED OFFICE (DO/EO/US) CONCERNING A FILING UNDER 35 U.S.C. 371

ATTORNEY'S DOCKET NUMBER
9847-0062-6X PCT

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR
09/554921

INTERNATIONAL APPLICATION NO.	INTERNATIONAL FILING DATE	PRIORITY DATE CLAIMED
PCT/EP98/07729	**30 NOVEMBER 1998**	**28 NOVEMBER 1997**

TITLE OF INVENTION
TRANSFORMER

APPLICANT(S) FOR DO/EO/US
Thorsten SCHUTTE, et al.

Applicant herewith submits to the United States Designated/Elected Office (DO/EO/US) the following items and other information:

1. ☒ This is a **FIRST** submission of items concerning a filing under 35 U.S.C. 371.
2. ☐ This is a **SECOND** or **SUBSEQUENT** submission of items concerning a filing under 35 U.S.C. 371.
3. ☒ This is an express request to begin national examination procedures (35 U.S.C. 371(f)) at any time rather than delay examination until the expiration of the applicable time limit set in 35 U.S.C. 371(b) and PCT Articles 22 and 39(1).
4. ☒ A proper Demand for International Preliminary Examination was made by the 19th month from the earliest claimed priority date.
5. ☒ A copy of the International Application as filed (35 U.S.C. 371 (c) (2))
   a. ☐ is transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☒ has been transmitted by the International Bureau.
   c. ☐ is not required, as the application was filed in the United States Receiving Office (RO/US).
6. ☐ A translation of the International Application into English (35 U.S.C. 371(c)(2)).
7. ☒ A copy of the International Search Report (PCT/ISA/210).
8. ☒ Amendments to the claims of the International Application under PCT Article 19 (35 U.S.C. 371 (c)(3))
   a. ☐ are transmitted herewith (required only if not transmitted by the International Bureau).
   b. ☐ have been transmitted by the International Bureau.
   c. ☐ have not been made; however, the time limit for making such amendments has NOT expired.
   d. ☒ have not been made and will not be made.
9. ☐ A translation of the amendments to the claims under PCT Article 19 (35 U.S.C. 371(c)(3)).
10. ☐ An oath or declaration of the inventor(s) (35 U.S.C. 371 (c)(4)).
11. ☐ A copy of the International Preliminary Examination Report (PCT/IPEA/409).
12. ☐ A translation of the annexes to the International Preliminary Examination Report under PCT Article 36 (35 U.S.C. 371 (c)(5)).

Items 13 to 18 below concern document(s) or information included:

13. ☒ An Information Disclosure Statement under 37 CFR 1.97 and 1.98.
14. ☐ An assignment document for recording. A separate cover sheet in compliance with 37 CFR 3.28 and 3.31 is included.
15. ☒ A **FIRST** preliminary amendment.
    A **SECOND** or **SUBSEQUENT** preliminary amendment.
16. ☒ A substitute specification.
17. ☐ A change of power of attorney and/or address letter.
18. ☐ Certificate of Mailing by Express Mail
19. ☒ Other items or information:

Request for Consideration of Documents Cited in International Search Report
Notice of Priority
Marked-up Copy of Specification
Form PTO-1449
Response to Petition Under 37 CFR 1.182
List of Related Cases

422 Rec'd PCT/PTO 22 MAY 2000

U.S. APPLICATION NO. (IF KNOWN, SEE 37 CFR	INTERNATIONAL APPLICATION NO.	ATTORNEY'S DOCKET NUMBER
09/554921	PCT/EP98/07729	9847-0062-6X PCT

20. The following fees are submitted:.

BASIC NATIONAL FEE (37 CFR 1.492 (a) (1) - (5)) :

CALCULATIONS PTO USE ONLY

- ☒ Search Report has been prepared by the EPO or JPO **$840.00**
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) **$670.00**
- ☐ No international preliminary examination fee paid to USPTO (37 CFR 1.482) but international search fee paid to USPTO (37 CFR 1.445(a)(2)) **$760.00**
- ☐ Neither international preliminary examination fee (37 CFR 1.482) nor international search fee (37 CFR 1.445(a)(2) paid to USPTO **$970.00**
- ☐ International preliminary examination fee paid to USPTO (37 CFR 1.482) and all claims satisfied provisions of PCT Article 33(2)-(4) **$96.00**

				CALCULATIONS	PTO USE ONLY
ENTER APPROPRIATE BASIC FEE AMOUNT =				**$840.00**	
Surcharge of **$130.00** for furnishing the oath or declaration later than ☐ 20 ☒ 30 months from the earliest claimed priority date (37 CFR 1.492 (e)).				**$130.00**	
CLAIMS	NUMBER FILED	NUMBER EXTRA	RATE		
Total claims	23 - 20 =	3	x $18.00	**$54.00**	
Independent claims	3 - 3 =	0	x $78.00	**$0.00**	
Multiple Dependent Claims **(check if applicable)**.			☐	**$0.00**	
TOTAL OF ABOVE CALCULATIONS =				**$1,024.00**	
Reduction of 1/2 for filing by small entity, if applicable. Verified Small Entity Statement must also be filed (Note 37 CFR 1.9, 1.27, 1.28) **(check if applicable)**. ☐				**$0.00**	
SUBTOTAL =				**$1,024.00**	
Processing fee of **$130.00** for furnishing the English translation later than ☐ 20 ☐ 30 months from the earliest claimed priority date (37 CFR 1.492 (f)). +				**$0.00**	
TOTAL NATIONAL FEE =				**$1,024.00**	
Fee for recording the enclosed assignment (37 CFR 1.21(h)). The assignment must be accompanied by an appropriate cover sheet (37 CFR 3.28, 3.31) **(check if applicable)**. ☐				**$0.00**	
TOTAL FEES ENCLOSED =				**$1,024.00**	
				Amount to be: refunded	$
				charged	$

☒ A check in the amount of **$1,024.00** to cover the above fees is enclosed.

☐ Please charge my Deposit Account No. in the amount of to cover the above fees. A duplicate copy of this sheet is enclosed.

☒ The Commissioner is hereby authorized to charge any fees which may be required, or credit any overpayment to Deposit Account No. **15-0030** A duplicate copy of this sheet is enclosed.

NOTE: Where an appropriate time limit under 37 CFR 1.494 or 1.495 has not been met, a petition to revive (37 CFR 1.137(a) or (b)) must be filed and granted to restore the application to pending status.

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May 22, 2000
DATE

9847-0062-6XPCT
ENKEL 8368

IN THE UNITED STATES PATENT & TRADEMARK OFFICE

IN RE APPLICATION OF: :

THORSTEN SCHUTTE, ET AL. : ATTN: APPLICATION DIVISION

SERIAL NO: NEW US PCT APPLICATION :
(based on PCT/EP98/07729)
FILED: HEREWITH :

FOR: TRANSFORMER :

PRELIMINARY AMENDMENT

ASSISTANT COMMISSIONER OF PATENTS
WASHINGTON, DC 20231

Prior to examination on the merits, please amend the above-identified application as follows:

IN THE CLAIMS

Please cancel Claims 1-22 without prejudice or disclaimer and add Claims 23-45 as follows:

--23. A transformer comprising:

a high voltage winding having turns; and

a low voltage winding having turns, wherein,

each of said high voltage winding and said low voltage winding being magnetically permeable and having a flexible conductor that is configured to contain an electric field, and the turns of the high voltage winding being intermixed with turns of the low voltage winding.

24. A transformer according to claim 23, wherein:

said low voltage winding being wound as a low voltage winding layer positioned between two corresponding adjacent high voltage winding layers.

25. A transformer according to claim 23, wherein:

respective layers of said high voltage winding and said low voltage winding being arranged in a repeated periodic pattern comprising one high voltage winding layer, followed by a low voltage winding layer, followed by two high voltage winding layers, and followed by repetitions of a low voltage winding layer, followed by another two high voltage winding layers.

26. A transformer according to claim 23, wherein:

at least one of the turns of the low voltage winding being split into subturns, each of said subturns being connected in parallel so as to reduce a difference between a number of high voltage winding turns and a number of low voltage winding turns.

27. A transformer according to claim 26, wherein:

each turn of the low voltage winding being split into parallel-connected subturns equal in number to a corresponding number of high voltage winding turns.

28. A transformer according to claim 27, wherein:

the turns of the high voltage winding and the turns in the low voltage winding being arranged symmetrically in a chessboard pattern, when viewed in a cross-section through said high voltage winding and said low voltage winding.

29. A transformer according to claim 23 wherein:

the flexible conductor comprises

a central electrical conductor;

a first layer having semi-conducting properties provided around said electrical conductor;

a solid insulating layer provided around said first layer; and

a second layer having semi-conducting properties provided around said solid insulating layer and configured to contain an electric field in the flexible conductor.

30. A transformer according to claim 29, wherein:

a potential on said first layer being substantially equal to a potential on the conductor.

31. A transformer according to claim 29, wherein:

said second layer being arranged to constitute substantially an equipotential surface surrounding said conductor.

32. A transformer according to claim 31, wherein:

said second layer being connected to a node at a predetermined potential.

33. A transformer according to claim 32, wherein:

said predetermined potential being ground potential.

34. A transformer according to claim 29, wherein:

at least one pair of said first layer and said solid insulating layer, and said solid insulating layer and said second layer having substantially equal thermal expansion coefficients.

35. A transformer according to claim 29, wherein:

said central electrical conductor comprises a plurality of strands of wire, only a minority of said strands being in electrical contact with each other.

36. A transformer according to claim 29, wherein:

each of said first layer, said solid insulating layer and said second layer being fixedly connected to a respective adjacent layer along substantially a whole connecting surface.

37. A transformer according to claim 29, wherein:

the flexible conductor further comprises a metal shield and a sheath.

38. A transformer according to claim 29, wherein:

a cross-section area of said central electrical conductor being in an inclusive range of 80 through 3000 mm^2.

39. A transformer according to claim 23, wherein:

an external diameter of the flexible conductor being in an inclusive range of 20 though 250 mm.

40. A transformer according to claim 23, further comprising:

struts of laminated magnetic material located between said high voltage winding and said low voltage winding.

41. A transformer according to claim 23, wherein:

the electric field contained in the flexible conductor being from a high voltage in said conductor in excess of 36 kV.

42. A transformer according to claim 23, wherein:

the flexible conductor being configured to handle a power in excess of 0.5 MVA.

43. A method of winding a transformer, comprising steps of:

simultaneously winding a high voltage flexible conductor and a low voltage flexible conductor configured to contain an electric field and being magnetically permeable to form a high voltage winding and a low voltage winding; and

intermixing turns of the high voltage winding with turns of the low voltage winding.

44. A method according to claim 43 wherein:

said simultaneously winding step comprises simultaneously unwinding the high voltage winding and the low voltage winding from respective drums and winding the high voltage flexible conductor and the low voltage flexible conductor on to a transformer drum.

45. A transformer comprising:

a high voltage winding having turns; and

a low voltage winding having turns, wherein,

each of said high voltage winding and said low voltage winding comprising means for handling a high voltage and containing an electric field associated with said high voltage, and

the turns of the high voltage winding being intermixed with turns of the low voltage winding.

said means for handling a high voltage includes means for setting an electric potential of an outer surface of at least one of said high voltage winding and said low voltage winding to ground potential.--

REMARKS

Favorable consideration of this Application as presently amended is respectfully requested.

Claims 23-45 are active in the present Application; Claims 1-22 having been canceled and Claims 23-45 added by way of the present Preliminary Amendment. The new claims have been added to be in a form that is consistent with U.S. claim drafting practice. It is therefore believed that no issues of new matter have been raised.

Entry of the enclosed substitute specification is respectfully requested. Because several amendments have been made to the specification, consistent with U.S. patent drafting practice, a marked-up copy of the original application is filed herewith. To the extent that any of the changes made by the substitute specification are deemed to be substantively inconsistent with the originally filed specification, these changes should be construed as typographical errors and the language included in the originally-filed PCT application should be construed as containing the controlling language.

The present document is one of a set of patent applications containing related technology as was discussed in "response to petition under 37 C.F.R. §1.182 seeking special treatment relating to an electronic search tool, and decision on petition under 37 C.F.R. §1.183 seeking waiver of requirements under 37 C.F.R. §1.98," filed in the holding application (U.S. Patent Application No. 09/147,325). Consistent with this decision, a copy of the decision is filed herewith. Also, an Information Disclosure Statement is filed herewith including a PTO Form 1449 with references that are included as part of the specially-created official digest in class 174. It is believed that submission of these materials and the reference to the holding application (Serial No. 09/147,325) is sufficient for the present Examiner to consider the references in the holding application, consistent with the decision.

Accordingly, examination on the merits of Claims 23-45 is believed to be in order, and an early and favorable action is respectfully requested.

Respectfully submitted,

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09/554921
Rec'd PCT/PTO 22 MAY 2000

TRANSFORMER

The present invention relates to a power transformer comprising at least one high voltage winding and one low voltage winding.

The term "power transformer" as used herein means a transformer having a rated output from a few hundred kVA to more than 1000 MVA and a rated voltage from 3-4 kV to very high transmission voltages, e.g. from 400-800 kV or higher.

Conventional power transformers are described in e.g. A.C.Franklin and D.P.Franklin, "The J & P Transformer Book, A Practical Technology of the Power Transformer", published by Butterworths, 11th edition, 1990. Problems related to internal electric insulation and related topics are discussed in e.g. H.P.Moser, "Transformerboard, Die Verwendung von Transformerboard in Grossleistungstransformatoren", published by H.Weidman AG, Rapperswil mit Gesamtherstellung: Birkhäuser AG, Basle, Switzerland.

In transmission and distribution of electric energy transformers are exclusively used for enabling exchange of electric energy between two or more electric systems. Transformers are available for powers from the 1 MVA region to the 1000 MVA region and for voltages up to the highest transmission voltages used today.

Conventional power transformers comprise a transformer core, often formed of laminated commonly oriented sheet, normally of silicon iron. The core is formed of a number of legs connected by yokes which together form one or more core windows. Transformers having such a core are usually called core transformers. A number of windings are provided around the core legs. In power transformers these windings are almost always arranged in a concentric configuration and distributed along the length of the core leg.

Other types of core structures are, however, known, e.g. so-called shell transformer structures, which normally have rectangular windings and rectangular leg sections disposed outside the windings.

Air-cooled conventional power transformers for lower power ranges are known. To render these transformers screen-protected an outer casing is often provided, which also reduces the external magnetic fields from the transformers.

Most power transformers are, however, oil-cooled the oil also serving as an insulating medium. An oil-cooled and oil-insulated conventional transformer is enclosed in an outer case which has to fulfil heavy demands. The construction of such a transformer with its associated circuit couplers, breaker elements and bushings is therefore complicated. The use of oil for cooling and insulation also complicates service of the transformer and constitutes an environmental hazard.

A so-called "dry" transformer without oil insulation and oil cooling and adapted for rated powers up to 1000 MVA with rated voltages from 3-4 kV and up to very high transmission voltages comprises windings formed from conductors such as shown in Figure 1. The conductor comprises central conductive means composed of a number of non-insulated (and optionally some insulated) wire strands 5. Around the conductive means there is an inner semiconducting casing 6 which is in contact with at least some of the non-insulated strands 5. This semiconducting casing 6 is in turn surrounded by the main insulation of the cable in the form of an extruded solid insulating layer 7. This insulating layer 7 is surrounded by an external semiconducting casing 8. The conductor area of the cable can vary between 80 and 3000 mm^2 and the external diameter of the cable between 20 and 250 mm.

Whilst the casings 6 and 8 are described as "semi-conducting" they are in practice formed from a base polymer mixed with carbon black or metallic particles and have a volume resistivity of between 1 and 10^5 Ω·cm, preferably between 10 and 500 Ω·cm. Suitable base polymers for the casings 6 and 8 (and for the insulating layer 7) include ethylene vinyl acetate copolymer/nitrile rubber, butyl grafted polythene, ethylene butyl acrylate copolymer, ethylene ethyl acrylate copolymer, ethylene propene rubber, polyethylenes of low density, poly butylene, poly methyl pentene, and ethylene acrylate copolymer.

The inner semiconducting casing 6 is rigidly connected to the insulating layer 7 over the entire interface therebetween. Similarly, the outer semiconducting casing 8 is rigidly connected to the insulating layer 7 over the entire interface therebetween. The casings 6 and 8 and the layer 7 form a solid insulation system and are conveniently extruded together around the wire strands 5.

Whilst the conductivity of the inner semiconducting casing 6 is lower than that of the electrically conductive wire strands 5, it is still sufficient to equalise the potential over its surface. Accordingly, the electric field is distributed uniformly around the circumference of the insulating layer 7 and the risk of localised field enhancement and partial discharge is minimised.

The potential at the outer semiconducting casing 8, which is conveniently at zero or ground or some other controlled potential, is equalised at this value by the conductivity of the casing. At the same time, the semi-conducting casing 8 has sufficient resistivity to enclose the electric field. In view of this resistivity, it is desirable to connect the conductive polymeric casing to ground, or some other controlled potential, at intervals therealong.

The transformer according to the invention can be a one-, three- or multi-phase transformer and the core can be of any design. Figure 2 shows a three-phase laminated core transformer. The core is of conventional design and comprises three core legs 9, 10, 11 and joining yokes 12, 13.

The windings are concentrically wound around the core legs. In the transformer of Figure 2 there are three concentric winding turns 14, 15, 16. The innermost winding turn 14 can represent the primary winding and the two other winding turns 15,16 the secondary winding. To make the Figure more clear such details as connections for the windings are left out. Spacing bars 17, 18 are provided at certain locations around the windings. These bars 17, 18 can be made of insulating material to define a certain space between the winding turns 14, 15, 16 for cooling, retention etc. or be made of an electrically conducting material to form a part of a grounding system of the windings 14, 15, 16.

The mechanical design of the individual coils of a transformer must be such that they can withstand forces resulting from short circuit currents. As these forces can be very high in a power transformer, the coils must be distributed and proportioned to give a generous margin of error and for that reason the coils cannot be designed so as to optimize performance in normal operation.

The main aim of the present invention is to alleviate the above mentioned problems relating to short circuit forces in a dry transformer.

This aim is achieved by a transformer as defined in claim 1.

By manufacturing the transformer windings from a conductor having practically no electric fields outside an outer semiconducting casing thereof, the high and low voltage windings can be easily mixed in an arbitrary way for minimizing the short circuit forces. Such mixing would be unfeasible in the absence of the semiconducting casing or other electric field containing means, and would therefore be considered impossible in a conventional oil-filled power transformer, because the insulation of the windings would not withstand the electric field existing between the high and low voltage windings.

It is also possible to reduce the distributed inductance and design the transformer core for the optimum match between window size and core mass.

According to an embodiment of the invention at least some of the turns of the low voltage winding are each split into a number of subturns connected in parallel for reducing the difference between the number of high voltage winding turns and the total number of low voltage winding turns to make the mixing of high voltage winding turns and low voltage winding turns as uniform as possible. Preferably, each turn of the low voltage winding is split into such a number of subturns, connected in parallel, such that the total number of low voltage winding turns is equal to the number of high voltage winding turns. High voltage and low voltage winding turns can then be mixed in a uniform manner such that the magnetic field generated by the low voltage winding turns substantially cancels the magnetic field from high voltage winding turns.

According to another advantageous embodiment, the turns of the high voltage winding and the turns of the low voltage winding are arranged symmetrically in a chessboard pattern, as seen in cross-section through the windings. This is an optimum arrangement for obtaining an efficient mutual cancellation of magnetic fields from the low and high voltage windings and thus an optimum arrangement for reducing the short circuit forces of the coils.

According to still another advantageous embodiment, at least two adjacent layers have substantially equal thermal expansion coefficients. In this way thermal damages to the winding is avoided.

Another aspect of the invention provides a method of winding a transformer as defined in claim 18.

To explain the invention in more detail, embodiments of the transformer according to the invention will now be described by way of example only with reference to the drawings in which:

Figure 1 shows an example of the cable used in the windings of the transformer according to the invention;

Figure 2 shows a conventional three-phase transformer;

Figures 3 and 4 show in cross-section different examples of the arrangement of the low and high voltage windings of the transformer of the invention; and

Figure 5 shows a method of winding the transformer.

Figure 3 is a cross-section through the portion of the windings of a power transformer according to the invention within the transformer core 22. A layer of a low voltage winding 26 is located between two layers of a high voltage winding 28. In this embodiment the transformation ratio is 1:2.

The direction of the current in the low voltage winding 26 is opposite to the direction of the current in the high voltage winding 28 and the resulting forces from the currents in the low and high voltage winding consequently partially cancel each other. This possibility of reducing the effect of current induced forces is of great importance, especially in case of a short circuit.

Struts 27 of laminated magnetic material, including spacers 29 providing air gaps, are located between the windings 26, 28 for improving transformer efficiency.

Cancellation of short circuit forces can be improved even further by splitting the turns of the low voltage winding into a number of subturns connected in parallel, preferably such that the total number of low voltage turns becomes equal to the number of high voltage winding turns. Thus, if the transformation ratio amounts to e.g. 1:3 each turn of the low voltage winding is split into three subturns. It is then possible to mix the low and high voltage windings in a more uniform pattern. An optimum arrangement of the windings is shown in Figure 4, where low and high voltage winding turns 30 and 32 respectively are arranged symmetrically in a chessboard pattern. In this embodiment the magnetic fields from each turn of the low and high voltage windings 30, 32 substantially cancel each other and short circuit forces are almost completely cancelled.

When splitting a winding turn into a number of subturns the conducting area of each subturn can be reduced correspondingly since the sum of the current intensities in the subturns remains equal to the current intensity in the original winding turn. Thus no more conducting material, (normally copper), is needed when splitting the winding turns, provided that other conditions are unchanged.

Figure 5 schematically shows how the transformer of the invention can be wound. A first drum 40 carries a high voltage conductor 42 and a second drum 44 carries a low voltage conductor 46. The conductors 42, 46 are unwound from the drums 46, 44 and wound onto a transformer drum 48, all three drums 40, 44, 48 rotating simultaneously. Thus the high and low voltage conductors can easily be intermixed. Joints can be provided between different winding layers.

In the transformer of the invention the magnetic energy and hence the stray magnetic field in the windings is reduced. A wide range of impedances can be chosen.

The electrical insulation systems of the windings of a transformer according to the invention are intended to be able to handle very high voltages and the consequent electric and thermal loads which may arise at these voltages. By way of example, power transformers according to the invention may have rated powers in excess of 0.5 MVA, preferably in excess of 10 MVA, more preferably greater than 30 MVA and up to 1000 MVA and have rated voltages from 3 - 4 kV, in particular in excess of 36 kV, and preferably more than 72.5 kV up to very high transmission voltages of from 400 - 800 kV or higher. At high operating voltages, partial discharges, or PD, constitute a serious problem for known insulation systems. If cavities or pores are present in the insulation, internal corona discharge may arise whereby the insulating material is gradually degraded eventually leading to breakdown of the insulation. The electric load on the electrical insulation in use of a transformer according to the present invention is reduced by ensuring that the inner first layer of the insulation system which has semi-conducting properties is at substantially the same electric potential as conductors of the central electrically conductive means which it surrounds and the outer second layer of the insulation system which has semi-conducting properties is at a controlled, e.g. earth, potential. Thus the electric field in the solid electrically insulating layer between these inner and outer layers is distributed substantially uniformly over the thickness of the intermediate layer. By having materials with similar thermal properties and with few defects in these layers of the insulation system, the possibility of PD is reduced at given operating voltages. The windings of the transformer can thus be designed to withstand very high operating voltages, typically up to 800 kV or higher.

Although it is preferred that the electrical insulation should be extruded in position, it is possible to build up an electrical insulation system from tightly wound, overlapping layers of film or sheet-like material. Both the semiconducting layers and the electrically insulating layer can be formed in this manner. An insulation system can be made of an all-synthetic film with inner and outer semiconducting layers or portions made of polymeric thin film of, for example, PP, PET, LDPE or HDPE with embedded conducting particles, such as carbon black or metallic particles and with an insulating layer or portion between the semiconducting layers or portions.

For the lapped concept a sufficiently thin film will have butt gaps smaller than the so-called Paschen minima, thus rendering liquid impregnation unnecessary. A dry, wound multilayer thin film insulation has also good thermal properties.

Another example of an electrical insulation system is similar to a conventional cellulose based cable, where a thin cellulose based or synthetic paper or non-woven material is lap wound around a conductor. In this case the semiconducting layers, on either side of an insulating layer, can be made of cellulose paper or non-woven material made from fibres of insulating material and with conducting particles embedded. The insulating layer can be made from the same base material or another material can be used.

Another example of an insulation system is obtained by combining film and fibrous insulating material, either as a laminate or as co-lapped. An example of this insulation system is the commercially available so-called paper polypropylene laminate, PPLP, but several other combinations of film and fibrous parts are possible. In these systems various impregnations such as mineral oil can be used.

CLAIMS

1. A power transformer comprising at least one high voltage winding and one low voltage winding, **characterised in** that each of said windings comprises a flexible conductor having electric field containing means but which is magnetically permeable and in that the windings are intermixed such that turns of the high voltage winding are mixed with turns of the low voltage winding.

2. A transformer according to claim 1, **characterised in** that said low voltage winding is wound as a low voltage winding layer positioned between two corresponding adjacent high voltage winding layers.

3. A transformer according to claim 1 or 2, **characterised in** that said windings are arranged in a repeated periodic pattern of one high voltage winding layer, followed by a low voltage winding layer, followed by two high voltage winding layers, followed by a low voltage winding layer, followed by two high voltage winding layers, etc.

4. A transformer according to any one of claims 1 to 3, **characterised in** that each one of at least some of the turns of the low voltage winding is split into a number of subturns connected in parallel for reducing the difference between the number of high voltage winding turns and the total number of low voltage winding turns.

5. A transformer according to claim 4, **characterised in** that each turn of the low voltage winding is split into a number of parallel-connected subturns equal to the number of high voltage winding turns.

6. A transformer according to claim 5, **characterised in** that the turns of the high voltage winding and the turns in the low voltage winding are arranged symmetrically in a

chessboard pattern, as seen in a cross-section through the windings.

7. A transformer according to any one of the preceding claims, **characterised in** that the conductor comprises central electrically conductive means, a first layer having semi-conducting properties provided around said conductive means, a solid insulating layer provided around said first layer, and field containing means comprising a second layer having semi-conducting properties provided around said insulating layer.

8. A transformer according to claim 7, **characterised in** that the potential of said first layer is substantially equal to the potential of the conductor.

9. A transformer according to claim 7 or 8, **characterised in** that said second layer is arranged to constitute substantially an equipotential surface surrounding said conductor.

10. A transformer according to claim 9, **characterised in** that said second layer is connected to a predetermined potential.

11. A transformer according to claim 10, **characterised in** that said predetermined potential is ground potential.

12. A transformer according to any one of claims 7 to 11, **characterised in** that at least two adjacent layers have substantially equal thermal expansion coefficients.

13. A transformer according to any one of claims 7 to 12, **characterised in** that said central conductive means comprises a plurality of strands of wire, only a minority of said strands being in electrical contact with each other.

14. A transformer according to any one of claims 7 to 13, **characterised in** that each of said three layers is fixedly connected to the adjacent layers along substantially the whole connecting surface.

15. A transformer according to any one of claims 7 to 14, **characterised in** that the conductor also comprises a metal shield and a sheath.

16. A transformer according to any one of claims 7 to 15, **characterised in** that the cross-section area of the central conductive means is from 80 to 3000 mm^2.

17. A transformer according to any one of the preceding claims, **characterised in** that the external diameter of the conductor is from 20 to 250 mm.

18. A transformer according to any one of the preceding claims, **characterised in** that struts (27) of laminated magnetic material are located between the windings.

19. A transformer according to any one of the preceding claims, **characterised in** that the electric field containing means is designed for high voltage, suitably in excess of 10 kV, in particular in excess of 36 kV, and preferably more than 72.5 kV up to very high transmission voltages, such as 400 kV to 800 kV or higher.

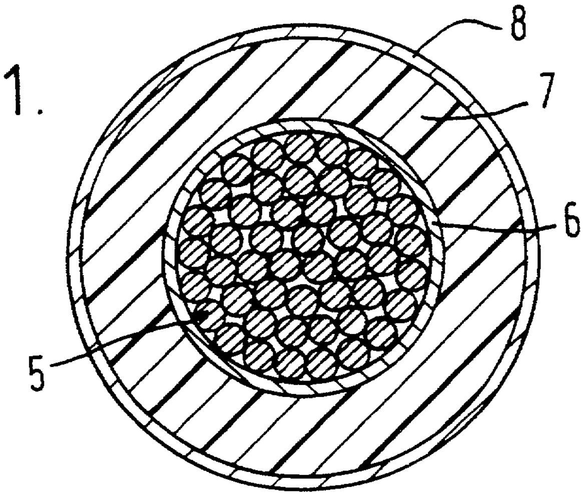
20. A transformer according to any one of the preceding claims, **characterised in** that the electric field containing means is designed for a power range in excess of 0.5 MVA, preferably in excess of 30 MVA and up to 1000 MVA.

21. A method of winding a power transformer, comprising simultaneously winding high voltage and low voltage flexible conductors having electric field containing means but which are magnetically permeable, such that turns

of the high voltage winding are intermixed with turns of the low voltage winding.

22. A method according to claim 19, **characterised in** that the high voltage and low voltage conductors are simultaneously unwound from respective drums and wound on to a transformer drum.

FIG.1.



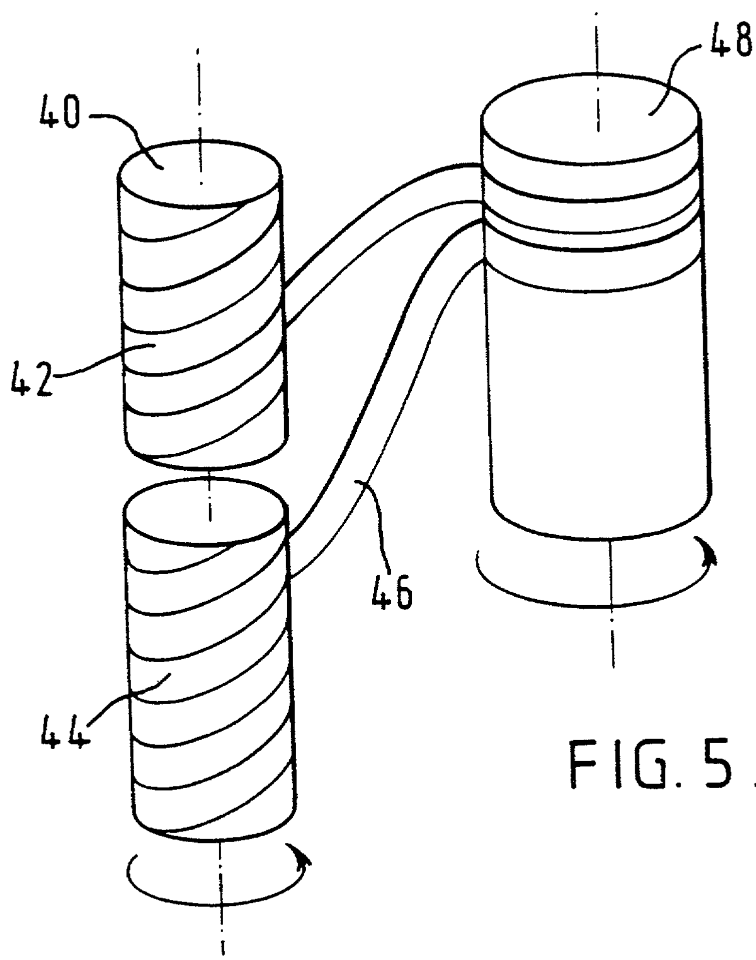


FIG.5.

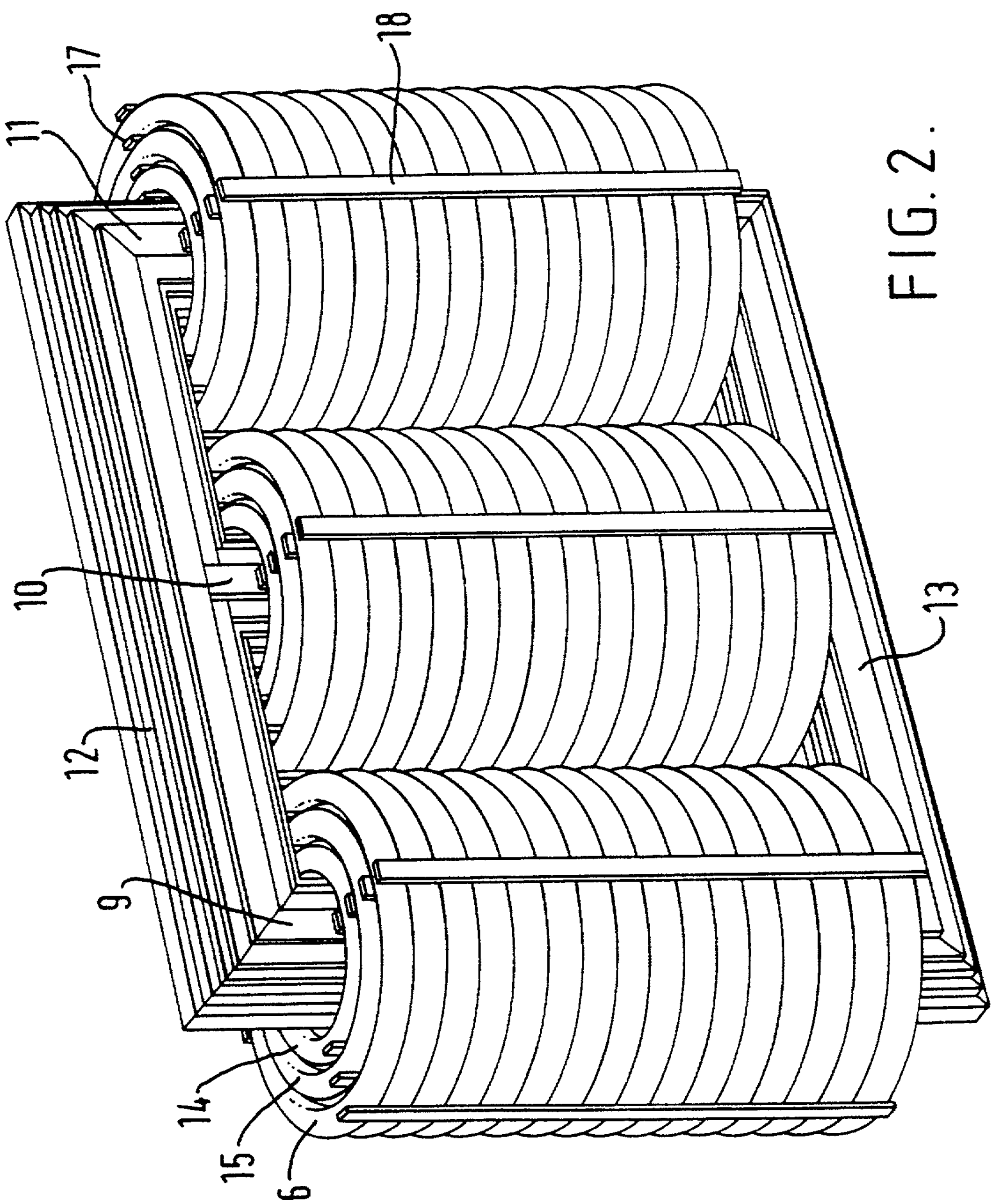
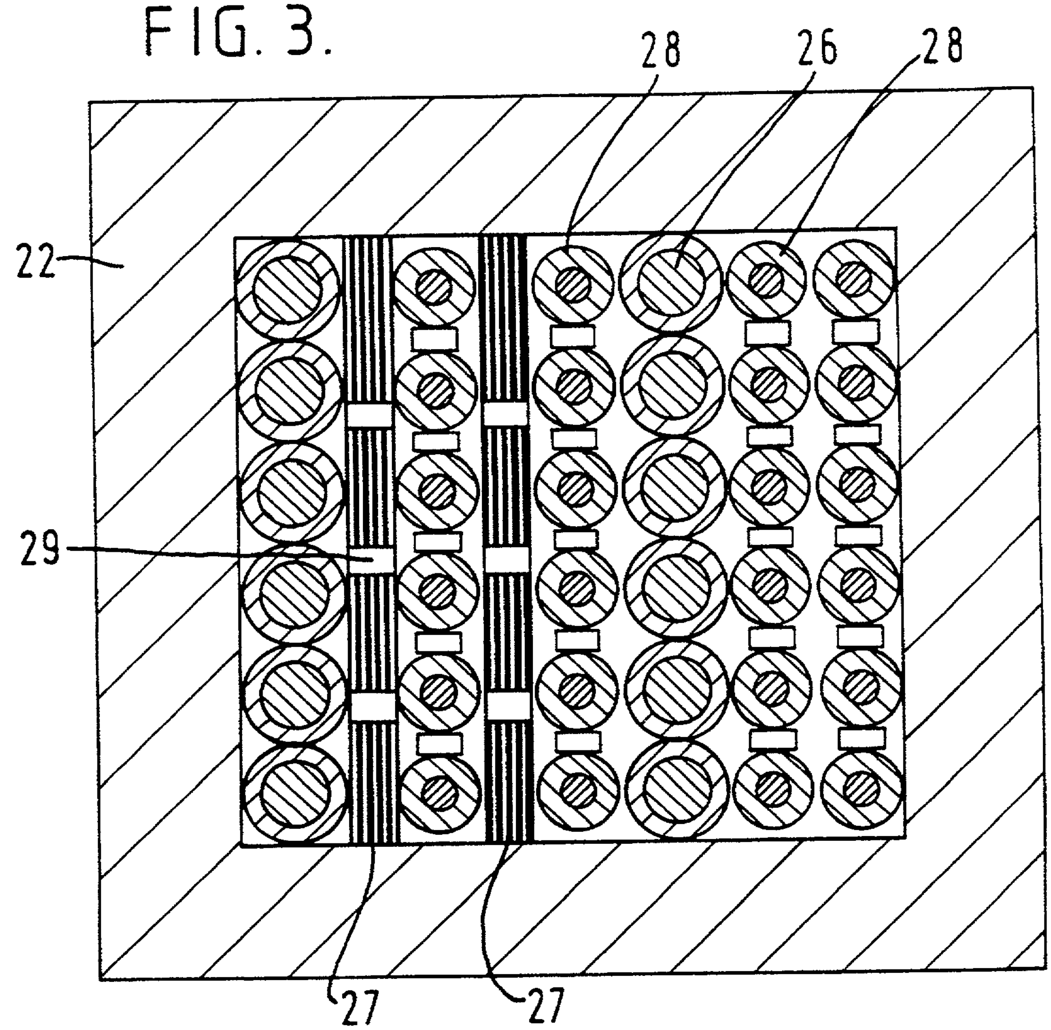


FIG. 2.

FIG. 3.



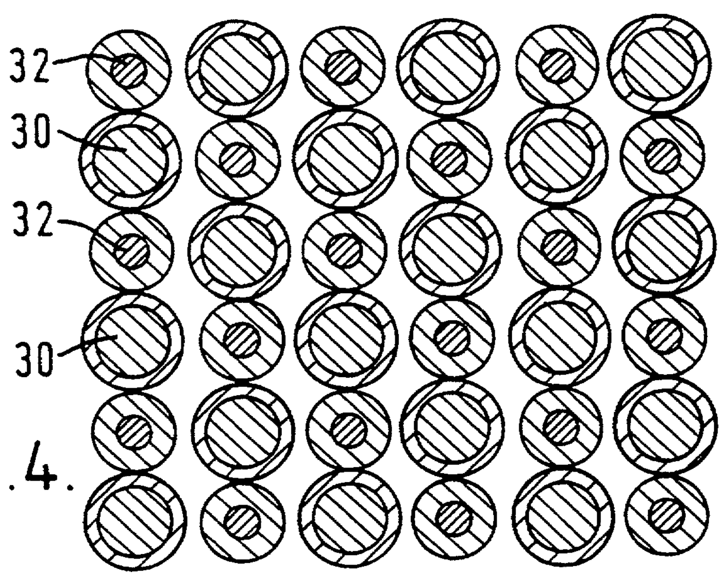


FIG.4.

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SUBSTITUTE SPECIFICATION

9847-0062-6xPCT
ENKEL 8368

TITLE OF THE INVENTION

TRANSFORMER

CROSS REFERENCE TO RELATED PATENT DOCUMENTS

The present document is based on published international patent application No. WO 99/28923, the entire contents of which being incorporated herein by reference.

BACKGROUND OF THE INVENTION

Field of the Invention:

The present invention relates to a transformer having at least one high voltage winding and one low voltage winding. The invention is applicable to power transformers having rated outputs from a few hundred kVA to more than 1000 MVA and rated voltages from 3-4 kV to very high transmission voltages, e.g. from 400-800 kV or higher.

Discussion of the Background:

Conventional power transformers are described in, e.g., A.C. Franklin and D.P.Franklin, "The J & P Transformer Book, A Practical Technology of the Power Transformer", published by Butterworths, 11th edition, 1990. Problems related to internal electric insulation and related topics are discussed in, e.g., H.P.Moser, "Transformerboard, Die Verwendung von Transformerboard in Grossleistungstransformatoren", published by H.Weidman AG, Rapperswil mit Gesamtherstellung: Birkhäuser AG, Basle, Switzerland.

In transmission and distribution of electric energy transformers are exclusively used for enabling exchange of electric energy between two or more electric systems. Transformers are available for powers from the 1 VA region to the 1000 MVA region and for voltages up to the highest transmission voltages used today.

Conventional power transformers include a transformer core, often formed of laminated commonly oriented sheet, normally of silicon iron. The core is formed of a number of legs connected by yokes which together form one or more core windows. Transformers having such a core are usually called core transformers. A number of windings are provided around the core legs. In power transformers, these windings are almost always arranged in a concentric configuration and distributed along the length of the core leg.

Other types of core structures are, however, known, e.g. so-called shell transformer structures, which normally have rectangular windings and rectangular leg sections disposed outside the windings.

Air-cooled conventional power transformers for lower power ranges are known. To render these transformers screen-protected an outer casing is often provided, which also reduces the external magnetic fields from the transformers.

Most power transformers are, however, oil-cooled the oil also serving as an insulating medium. An oil-cooled and oil-insulated conventional transformer is enclosed in an outer case which has to fulfil heavy demands. The construction of such a transformer with its associated circuit couplers, breaker elements and bushings is therefore complicated. The use of oil for cooling and insulation also complicates service of the transformer and constitutes an environmental hazard.

A so-called "dry" transformer without oil insulation and oil cooling and adapted for rated powers up to 1000 MVA with rated voltages from 3-4 kV and up to very high transmission voltages has windings formed from conductors such as shown in Figure 1. The conductor has a central conductor composed of a number of non-insulated (and optionally some insulated) wire strands 5. Around the conductor there is an inner semiconducting casing 6 which is in contact with at least some of the non-insulated strands 5. This semiconducting casing 6 is in turn surrounded by the main insulation of the cable in the form of an extruded solid insulating layer 7. This insulating layer 7 is surrounded by an external semiconducting casing 8. The conductor area of the cable can vary between 80 and 3000 mm^2 and the external diameter of the cable between 20 and 250 mm.

Whilst the casings 6 and 8 are described as "semiconducting" they are in practice formed from a base polymer mixed with carbon black or metallic particles and have a resistivity of between 1 and 10^5 Ωcm, preferably between 10 and 500 Ωcm. Suitable base polymers for the casings 6 and 8 (and for the insulating layer 7) include ethylene vinyl acetate copolymer/nitrile rubber, butyl grafted polythene, ethylene butyl acrylate copolymer, ethylene ethyl acrylate copolymer, ethylene propene rubber, polyethylenes of low density, poly butylene, poly methyl pentene, and ethylene acrylate copolymer.

The inner semiconducting casing 6 is rigidly connected to the insulating layer 7 over the entire interface therebetween. Similarly, the outer semiconducting casing 8 is rigidly connected to the insulating layer 7 over the entire interface therebetween. The casings 6 and 8 and the layer 7 form a solid insulation system and are conveniently extruded together around the wire strands 5.

Whilst the conductivity of the inner semiconducting casing 6 is lower than that of the electrically conductive wire strands 5, it is still sufficient to equalise the potential over its surface. Accordingly, the electric field is distributed uniformly around the circumference of the insulating layer 7 and the risk of localised field enhancement and partial discharge is minimised.

The potential at the outer semiconducting casing 8, which is conveniently at zero or ground or some other controlled potential, is equalised at this value by the conductivity of the casing. At the same time, the semiconducting casing 8 has sufficient resistivity to enclose the electric field. In view of this resistivity, it is desirable to connect the conductive polymeric casing to ground, or some other controlled potential, at intervals therealong.

The transformer according to the invention can be a one-, three- or multi-phase transformer and the core can be of any design. Figure 2 shows a three-phase laminated core transformer. The core is of conventional design and includes three core legs 9, 10, 11 and joining yokes 12, 13.

The windings are concentrically wound around the core legs. In the transformer of Figure 2 there are three concentric winding turns 14, 15, 16. The innermost winding turn 14 can represent the primary winding and the two other winding turns 15,16 the secondary winding. To make the Figure more clear such details as connections for the windings are left out. Spacing bars 17,18 are provided at certain locations around the windings. These bars 17,18 can be made of insulating material to define a certain space between the winding turns 14, 15, 16 for cooling, retention etc. or be made of an electrically conducting material to form a part of a grounding system of the windings 14, 15, 16.

The mechanical design of the individual coils of a transformer must be such that they can withstand forces resulting from short circuit currents. As these forces can be very high in a power transformer, the coils must be distributed and proportioned to give a generous margin of error and for that reason the coils cannot be designed so as to optimize performance in normal operation.

SUMMARY OF THE INVENTION

The main aim of the present invention is to alleviate the above mentioned problems relating to short circuit forces in a dry transformer.

This aim is achieved by a transformer having at least one high voltage winding and one low voltage winding. Each of the windings has a flexible conductor and is capable of containing an electric field. Each winding is magnetically permeable and the windings are intermixed such that turns of the high voltage winding are mixed with turns of the low voltage winding.

By manufacturing the transformer windings from a conductor having practically no electric fields outside an outer semiconducting casing thereof, the high and low voltage windings can be easily mixed in an arbitrary way for minimizing the short circuit forces. Such mixing would be unfeasible in the absence of the semiconductor casing or other mechanism for containing the electric field, and therefore would be considered impossible in a conventional oil-filled power transformer, because the insulation of the windings would not withstand the electrioc field existing between the high and low voltage windings.

It is also possible to reduce the distributed inductance and design the transformer core for the optimum match between window size and core.

According to an embodiment of the invention at least some of the turns of the low voltage winding are each split into a number of subturns connected in parallel for reducing the difference between the number of high voltage winding turns and the total number of low voltage winding turns to make the mixing of high voltage winding turns and low voltage winding turns as uniform as possible. Preferably, each turn of the low voltage winding is split into such a number of subturns, connected in parallel, such that the total number of low voltage winding turns is equal to the number of high voltage winding turns. High voltage and low voltage winding turns can then be mixed in a uniform manner such that the magnetic field generated by the low voltage winding turns substantially cancels the magnetic field from high voltage winding turns.

According to another advantageous embodiment, the turns of the high voltage winding and the turns of the low voltage winding are arranged symmetrically in a chessboard pattern, as seen in cross-section through the windings. This is an optimum arrangement for obtaining an efficient mutual cancellation of magnetic fields from the low and high voltage windings and thus an optimum arrangement for reducing the short circuit forces of the coils.

According to still another advantageous embodiment, at least two adjacent layers have substantially equal thermal expansion coefficients. In this way thermal damages to the winding is avoided.

Another aspect of the invention provides a method of winding a transformer that includes simultaneously winding high voltage and low voltage flexible conductors capable of containing an electric field but which are magnetically permeable, such that turns of the high voltage winding are intermixed with turns of the low voltage winding.

BRIEF DESCRIPTION OF THE DRAWINGS

To explain the invention in more detail, embodiments of the transformer according to the invention will now be described by way of example only with reference to the drawings in which:

Figure 1 shows an example of the cable used in the windings of the transformer according to the invention;

Figure 2 shows a conventional three-phase transformer;

Figures 3 and 4 show in cross-section different examples of the arrangement of the low and high voltage windings of the transformer of the invention; and

Figure 5 shows a method of winding the transformer.

DETAILED DESCRIPTION OF THE PREFERRED EMBODIMENTS

Figure 3 is a cross-section through the portion of the windings of a power transformer according to the invention within the transformer core 22. A layer of a low voltage winding 26 is located between two layers of a high voltage winding 28. In this embodiment the transformation ratio is 1:2.

The direction of the current in the low voltage winding 26 is opposite to the direction of the current in the high voltage winding 28 and the resulting forces from the currents in the low and high voltage winding consequently partially cancel each other. This possibility of reducing the effect of current induced forces is of great importance, especially in case of a short circuit.

Struts 27 of laminated magnetic material, including spacers 29 providing air gaps, are located between the windings 26, 28 for improving transformer efficiency.

Cancellation of short circuit forces can be improved even further by splitting the turns of the low voltage winding into a number of subturns connected in parallel, preferably such that the total number of low voltage turns becomes equal to the number of high voltage winding turns. Thus, if the transformation ratio amounts to e.g. 1:3 each turn of the low voltage winding is split into three subturns. It is then possible to mix the low and high voltage windings in a more uniform pattern. An optimum arrangement of the windings is shown in Figure 4, where low and high voltage winding turns 30 and 32 respectively are arranged symmetrically in a chessboard pattern. In this embodiment the magnetic fields from each turn of the low and high voltage windings 30, 32 substantially cancel each other and short circuit forces are almost completely cancelled.

When splitting a winding turn into a number of subturns the conducting area of each subturn can be reduced correspondingly since the sum of the current intensities in the subturns remains equal to the current intensity in the original winding turn. Thus, no more conducting material (normally copper) is needed when splitting the winding turns, provided that other conditions are unchanged.

Figure 5 schematically shows how the transformer of the invention can be wound. A first drum 40 carries a high voltage conductor 42 and a second drum 44 carries a low voltage conductor 46. The conductors 42, 46 are unwound from the drums 46, 44 and wound onto a transformer drum 48, all three drums 40, 44, 48 rotating simultaneously. Thus the high and low voltage conductors can easily be intermixed. Joints can be provided between different winding layers.

In the transformer of the invention the magnetic energy and hence the stray magnetic field in the windings is reduced. A wide range of impedances can be chosen.

The electrical insulation systems of the windings of a transformer according to the invention are intended to be able to handle very high voltages and the consequent electric and thermal loads which may arise at these voltages. By way of example, power transformers according to the invention may have rated powers from a few hundred kVA up to more than 1000 MVA and have rated voltages from 3 - 4 kV up to very high transmission voltages of from 400 - 800 kV or more. At high operating voltages, partial discharges, or PD, constitute a serious problem for known insulation systems. If cavities or pores are present in the insulation, internal corona discharge may arise whereby the insulating material is gradually degraded eventually leading to breakdown of the insulation. The electric load on the electrical insulation in use of a transformer according to the present invention is reduced by ensuring that the inner first layer of the insulation system which has semiconducting properties is at substantially the same electric potential as conductors of the central electrically conductor which it surrounds and the outer second layer of the insulation system which has semiconducting properties is at a controlled, e.g. earth, potential. Thus the electric field in the solid electrically insulating layer between these inner and outer layers is distributed substantially uniformly over the thickness of the intermediate layer. By having materials with similar thermal properties and with few defects in these layers of the insulation system, the possibility of PD is reduced at given operating voltages. The windings of the transformer can thus be designed to withstand very high operating voltages, typically up to 800 kV or higher.

Although it is preferred that the electrical insulation should be extruded in position, it is possible to build up an electrical insulation system from tightly wound, overlapping layers of film or sheet-like material. Both the semiconducting layers and the electrically insulating layer can be formed in this manner. An insulation system can be made of an all-synthetic film with inner and outer semiconducting layers or portions made of polymeric thin film of, for example, PP, PET, LDPE, or HDPE with embedded conducting particles, such as carbon black or metallic particles and with an insulating layer or portion between the semiconducting layers or portions.

For the lapped concept a sufficiently thin film will have butt gaps smaller than the so-called Paschen minima, thus rendering liquid impregnation unnecessary. A dry, wound multilayer thin film insulation has also good thermal properties.

Another example of an electrical insulation system is similar to a conventional cellulose based cable, where a thin cellulose based or synthetic paper or non-woven material is lap wound around a conductor. In this case the semiconducting layers, on either side of an insulating layer, can be made of cellulose paper or non-woven material made from fibers of insulating material and with conducting particles embedded. The insulating layer can be made from the same base material or another material can be used.

Another example of an insulation system is obtained by combining film and fibrous insulating material, either as a laminate or as co-lapped. An example of this insulation system is the commercially available so-called paper polypropylene laminate, PPLP, but several other combinations of film and fibrous parts are possible. In these systems various impregnations such as mineral oil can be used.

CLAIMS

1. A transformer comprising at least one high voltage winding and one low voltage winding, **characterised in** that each of said windings comprises a flexible conductor having electric field containing means but which is magnetically permeable and in that the windings are intermixed such that turns of the high voltage winding are mixed with turns of the low voltage winding.

2. A transformer according to claim 1, **characterised in** that said low voltage winding is wound as a low voltage winding layer positioned between two corresponding adjacent high voltage winding layers.

3. A transformer according to claim 1 or 2, **characterised in** that said windings are arranged in a repeated periodic pattern of one high voltage winding layer, followed by a low voltage winding layer, followed by two high voltage winding layers, followed by a low voltage winding layer, followed by two high voltage winding layers, etc.

4. A transformer according to any one of claims 1 to 3, **characterised in** that each one of at least some of the turns of the low voltage winding is split into a number of subturns connected in parallel for reducing the difference between the number of high voltage winding turns and the total number of low voltage winding turns.

5. A transformer according to claim 4, **characterised in** that each turn of the low voltage winding is split into a number of parallel-connected subturns equal to the number of high voltage winding turns.

6. A transformer according to claim 5, **characterised in** that the turns of the high voltage winding and the turns in the low voltage winding are arranged symmetrically in a chessboard pattern, as seen in a cross-section through the windings.

7. A transformer according to any one of the preceding claims, **characterised in** that the conductor comprises central electrically conductive means, a first layer having semi-conducting properties provided around said conductive means, a solid insulating layer provided around said first layer, and field containing means comprising a second layer having semi-conducting properties provided around said insulating layer.

8. A transformer according to claim 7, **characterised in** that the potential of said first layer is substantially equal to the potential of the conductor.

9. A transformer according to claim 7 or 8, **characterised in** that said second layer is arranged to constitute substantially an equipotential surface surrounding said conductor.

10. A transformer according to claim 9, **characterised in** that said second layer is connected to a predetermined potential.

11. A transformer according to claim 10, **characterised in** that said predetermined potential is ground potential.

12. A transformer according to any one of claims 7 to 11, **characterised in** that at least two adjacent layers have substantially equal thermal expansion coefficients.

13. A transformer according to any one of claims 7 to 12, **characterised in** that said central conductive means comprises a plurality of strands of wire, only a minority of said strands being in electrical contact with each other.

14. A transformer according to any one of claims 7 to 13, **characterised in** that each of said three layers is fixedly connected to the adjacent layers along substantially the whole connecting surface.

15. A transformer according to any one of claims 7 to 14, **characterised in** that the conductor also comprises a metal shield and a sheath.

16. A transformer according to any one of claims 7 to 15, **characterised in** that the cross-section area of the central conductive means is from 80 to 3000 mm^2.

17. A transformer according to any one of the preceding claims, **characterised in** that the external diameter of the conductor is from 20 to 250 mm.

18. A transformer according to any one of the preceding claims, **characterised in** that struts (27) of laminated magnetic material are located between the windings.

19. A transformer according to any one of the preceding claims, **characterised in**

that the electric field containing means is designed for high voltage, suitably in excess of 10 kV, in particular in excess of 36 kV, and preferably more than 72.5 kV up to very high transmission voltages, such as 400 kV to 800 kV or higher.

20. A transformer according to any one of the preceding claims, **characterised in** that the electric field containing means is designed for a power range in excess of 0.5 MVA, preferably in excess of 30 MVA and up to 1000 MVA.

21. A method of winding a transformer, comprising simultaneously winding high voltage and low voltage flexible conductors having electric field containing means but which are magnetically permeable, such that turns of the high voltage winding are intermixed with turns of the low voltage winding.

22. A method according to claim 19, **characterised in** that the high voltage and low voltage conductors are simultaneously unwound from respective drums and wound on to a transformer drum.

ABSTRACT

A power transformer having at least one high voltage winding and one low voltage winding. Each of the windings includes at least one current-carrying conductor, a first layer having semiconducting properties provided around said conductor, a solid insulating layer provided around said first layer, and a second layer having semiconducting properties provided around said insulating layer. The windings are intermixed such that turns of the high voltage winding are mixed with turns of the low voltage winding.

9847-0062-6X PCT

Declaration, Power Of Attorney and Petition

WE (I) the undersigned inventor(s), hereby declare(s) that:

My residence, post office address and citizenship are as stated below next to my name,

We (I) believe that we are (I am) the original, first, and joint (sole) inventor(s) of the subject matter which is claimed and for which a patent is sought on the invention entitled

TRANSFORMER

the specification of which

☐ is attached hereto.

☒ was filed on 22 May 2000 as

Application Serial No. ______

and amended on ______.

☒ was filed as PCT international application

Number PCT/EP98/07729

on 30 November 1998,

and was amended under PCT Article 19

on ______ (if applicable).

We (I) hereby state that we (I) have reviewed and understand the contents of the above-identified specification, including the claims, as amended by any amendment referred to above.

We (I) acknowledge the duty to disclose information known to be material to the patentability of this application as defined in Section 1.56 of Title 37 Code of Federal Regulations.

We (I) hereby claim foreign priority benefits under 35 U.S.C. § 119(a)-(d) or § 365(b) of any foreign application(s) for patent or inventor's certificate, or § 365(a) of any PCT International application which designated at least one country other than the United States, listed below and have also identified below, by checking the box, any foreign application for patent or inventor's certificate, or PCT International application having a filing date before that of the application on which priority is claimed. Prior Foreign Application(s)

Application No.	Country	Day/Month/Year	Priority Claimed	
9725331.4	GREAT BRITAIN	28 November 1997	☒ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No
			☐ Yes	☐ No

We (I) hereby claim the benefit under Title 35, United States Code, § 119(e) of any United States provisional application(s) listed below.

(Application Number)	(Filing Date)
(Application Number)	(Filing Date)

We (I) hereby claim the benefit under 35 U.S.C. § 120 of any United States application(s), or § 365(c) of any PCT International application designating the United States, listed below and, insofar as the subject matter of each of the claims of this application is not disclosed in the prior United States or PCT International application in the manner provided by the first paragraph of 35 U.S.C. § 112, I acknowledge the duty to disclose information which is material to patentability as defined in 37 CFR § 1.56 which became available between the filing date of the prior application and the national or PCT International filing date of this application.

Application Serial No.	Filing Date	Status (pending, patented, abandoned)
PCT/EP98/07729	30 November 1998	

And we (I) hereby appoint: Norman F. Oblon, Reg. No. 24,618; Marvin J. Spivak, Reg. No. 24,913; C. Irvin McClelland, Reg. No. 21,124; Gregory J. Maier, Reg. No. 25,599; Arthur I. Neustadt, Reg. No. 24,854; Richard D. Kelly, Reg. No. 27,757; James D. Hamilton, Reg. No. 28,421; Eckhard H. Kuesters, Reg. No. 28,870; Robert T. Pous, Reg. No. 29,099; Charles L. Gholz, Reg. No. 26,395; Vincent J. Sunderdick, Reg. No. 29,004; William E. Beaumont, Reg. No. 30,996; Robert F. Gnuse, Reg. No. 27,295; Jean-Paul Lavalleye, Reg. No. 31,451; Stephen G. Baxter, Reg. No. 32,884; Robert W. Hahl, Reg. No. 33,893; Richard L. Treanor, Reg. No. 36,379; Steven P. Weihrouch, Reg. No. 32,829; John T. Goolkasian, Reg. No. 26,142; Richard L. Chinn, Reg. No. 34,305; Steven E. Lipman, Reg. No. 30,011; Carl E. Schlier, Reg. No. 34,426; James J. Kulbaski, Reg. No. 34,648; Richard A. Neifeld, Reg. No. 35,299; J. Derek Mason, Reg. No. 35,270; Surinder Sachar, Reg. No. 34,423; Christina M. Gadiano, Reg. No. 37,628; Jeffrey B. McIntyre, Reg. No. 36,867; Paul E. Rauch, Reg. No. 38,591; William T. Enos, Reg. No. 33,128; and Michael E. McCabe, Jr., Reg. No. 37,182; our (my) attorneys, with full powers of substitution and revocation, to prosecute this application and to transact all business in the Patent Office connected therewith; and we (I) hereby request that all correspondence regarding this application be sent to the firm of OBLON, SPIVAK, McCLELLAND, MAIER & NEUSTADT, P.C., whose Post Office Address is: Fourth Floor, 1755 Jefferson Davis Highway, Arlington, Virginia 22202.

We (I) declare that all statements made herein of our (my) own knowledge are true and that all statements made on information and belief are believed to be true; and further that these statements were made with the knowledge that willful false statements and the like so made are punishable by fine or imprisonment, or both, under Section 1001 of Title 18 of the United States Code and that such willful false statements may jeopardize the validity of the application or any patent issuing thereon.

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